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Technology for Sustainable Development: Creating Decent Jobs and Empowering Youth in Arab Countries

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Executive Summary

The objective of the present report is to determine the critical action required from Governments, the private sector and civil society in Arab countries in response to the exponential, frontier, or disruptive technologies sweeping the world, in order to maximize the benefits for sustainable development and lower risks of abuse and possible negative impact.

The United Nations General Assembly, in its resolution 72/242, recognized that the pace and scope of rapid technological change can have far-reaching implications – both positive and negative – for the achievement of sustainable development, requiring international and multi-stakeholder cooperation to benefit from opportunities and address challenges. A recent leadership report concluded that an integrated multidisciplinary approach was necessary and would require United Nations system-wide engagement on the basis of strategic coherence, common positioning and coordinated action across all pillars of United Nations work.[1] The United Nations is also expected to promote innovation in norm building and use its convening power to elevate the role of the private sector in normative discussions on peace and security.

The rapid exponential pace of innovation and technology development is changing the life of most people constantly. From the ubiquitous availability of mobile phones worldwide to the growing knowledge of human genetics, this is a time of great opportunity and uncertainty. Societies around the world embrace the freedom and access to information that technology provides, while expressing growing concerns that technology and innovation could make workers professionally redundant, people technologically dependent, communication security exposed and individuals socially isolated. And, for the first time in world history, this is a shared challenge across geography, incomes and demographics.

Advances in smart phones, 3D printers, social media, cloud computing, artificial intelligence, robotics, nanotechnology, online education, digital economy, renewable and efficient energy technologies, water saving and irrigation technologies, food production, smart cities, Internet of Things (IoT), climate change mitigation technologies and biotechnologies, all represent significant technological progress, in many cases revolutionary and disruptive.

Arab countries have undergone radical changes that will fundamentally alter the way people live, work and relate to one another. The change is partially due to a technological revolution that, if properly leveraged, could help to provide solutions to the region's numerous sustainability challenges, enforce its resilience priorities and create unprecedented development opportunities. Acknowledging those advancements, the opportunities they present and the challenges they might pose, is a key factor in devising regional and national policy recommendations. What remains to be seen are the implications of those technological advancements to the Arab region in terms that include, but are not limited to, peace, rehabilitation and reconstruction in conflict-afflicted countries, good governance, job creation, social interaction, mobility of people, productivity, sustainable management of natural resources, security, economic transactions and national cultural identities.

Technology and innovation will have an important impact on the economic issues facing the Arab region, from digitization, to jobs disrupted by automation and to the importance of access to capital in order to create a vibrant entrepreneurial ecosystem in new industries. But technology and innovation will also have an impact on other issues, from human development, rehabilitation and reconciliation, socialisation and inclusion, to women's empowerment, culture and youth.

It is important that Governments in the Arab region embrace a multi-step, multi-year plan of action for new categories of technologies as they arise. The impact of genetic engineering, for example, will be very different from the impact of the Internet. We cannot know exactly what such impact will be, or when it will take effect. Countries, with their diverse economic, social and political systems, need to formalize the system of innovation and standardize a policy framework through which a technology can be planned and monitored from laboratory to market, or from concept to ubiquity.

Governments have a crucial leadership role in convening stakeholders, regulating applications, and promoting proper use of tools and technologies that constitute pillars of the Fourth Industrial Revolution (4IR) for the good of society. The private sector should seize opportunities, develop solutions, innovate schemes and applications, and invest smartly. Civil society should facilitate suitable training, advocate ethical behaviour and public interest, monitor technology development and governance, blow whistles 'just in time', and use technologies optimally.

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I. Frontier Technologies: A Leap into the Third Millennium

The world is undergoing an unprecedented burst of technological advancement and innovation, made possible by rapid increases in computing power connected in what is known as the cloud, with farms of data centres and webs of sensors. The World Economic Forum (WEF) reported in 2018 that, since 2010, the healthcare sector alone attracted $145 billion in 1,800 start-ups.[2] Nearly every world leader has highlighted the opportunities and challenges brought about by a transformation called frontier technologies (FTs). FTs are those "that will reshape industry and communications and provide urgently needed solutions to global challenges like climate change" and have the potential to displace existing processes".[3] It is that disruptive characteristic and new outlook that hopes to eradicate chronic development challenges.

FTs are defined and shaped by context and can help to redefine and navigate "wicked problems".[4] If properly channelled in effective technology transfer efforts, today's technologies provide a unique opportunity to induce sustainable economic growth and social development. The United Nations recognized that fact, as highlighted in its preparations for the third Science, Technology, and Innovation for the Sustainable Development Goals (SDGs) Forum, to be held in June 2018 in New York.[5]

The Internet is connecting the world, including the Arab region, in ways that few tools have done before. Through social media, the entire Arab region communicates, discusses, shares and advocates in ways that were previously impossible. With current research breakthroughs and innovations in life sciences and agriculture, Arab countries could together solve common challenges facing food security, water availability, public health, clean energy, clean air and marine problems. In addition, the innovation and technology revolution has created opportunities that could be utilized for recovery and reconstruction in countries post conflict. The revolution could support economic diversification in the oil-rich Gulf region and countries in transition. Many FTs are already deployed in Arab countries' economic and social networks, including media, government services, industrial processes, health care, or knowledge platforms. For example, Sophia became the first robot citizen of Saudi Arabia in 2017.[6]

Technological breakthroughs have already had significant socioeconomic impacts, as various production sectors evolved from a labour-intensive and resource-hungry perspiration economy to a more productive and resource-efficient inspiration economy. It is difficult to imagine going forward while ignoring those FTs. Regional countries in conflict, under occupation or sanctioned are restricted in their ability to access and/or implement the exponential technologies needed to advance their economic and social goals.

A. What are they?

The Fourth Industrial Revolution (4IR), like the three major technology revolutions before it,[7] is creating new paradigms. It has led to artificial intelligence (AI) and machine learning, data science, location-based technologies (geospatial and aerospace), advanced robotics and drones, virtual or augmented and mixed reality systems, biotechnologies and nanomedicine, multidimensional printing, new materials and nanotechnology, neurotechnology, plus green and other technologies that are being introduced more quickly than absorption capacity. A 2017 report by PricewaterhouseCoopers says: "As the fastest-ever period of technological innovation, the 4IR presents great promise to leapfrog traditional development and accelerate the transition to a more sustainable urban future."[8]

Computing power has accelerated, with increasing miniaturisation. Computer devices are now embedded in items of daily life. Progress in other technologies is following similar paths. Manufacturing, for example, is using advanced physics and nanotechnology. Many major manufacturers are exploring methods of the maker movement, powered by rapid prototyping technologies such as 3D printers, which allow for rapid manufacturing and, increasingly, high levels of mass customization, in which the flexibility of custom-made products is combined with the capacity for mass production, generating lower unit costs. Remarkable advances in biotechnology are making it increasingly possible to carry out gene

editing in order to modify functions of living organisms. New technologies are making it possible and cheaper to access clean energy by implementing not only new renewables but also enabling more efficient use of energy resources such as hydrocarbons. AI has been an important area of research and development during the past 50 years, but the emphasis was on research rather than development. During the past 10 years, smart X (everything from shoes and clothes to cities) became market trends. The Internet of Everything became a marketing label for serious products such as medical monitoring devices and gaming gadgets. Once-theoretical scenarios are now tested on a large scale outside laboratory walls. Algorithms have been dusted down from the pages of published journals, those algorithms regarded not too long ago as almost impossible to implement using computing capacity available at the time.

B. Where are they?

Whether reading the number plate of a speeding car in streets of Arab countries or targeting online marketing to clients, AI algorithms are driving commercial and governmental systems to new frontiers. AI provides abilities for devices so that they can speak, listen, reason, and read in the Arabic language for the first time ever.

Arab countries have recognized their capacity to harness solar, wind and hydropower, and have begun to invest in those technologies. To reduce their carbon footprints, many are investigating cleaner and more efficient energy supply chains. Efficient smart grids can reduce emissions and usage. The countries of the Gulf Cooperation Council (GCC) have agreed on the importance of diversifying their economies beyond oil and gas. The medium- to long-term national strategic plans call for the creation of domestic private enterprises built on local talent, capital and regional opportunities. Many Arab countries with fewer resources were still able to rank high in competitiveness because of their policies for education and economic diversification.

Such policies would allow countries to create a critical mass of people trained in new technologies. In 2016, for example, the Egyptian Ministry of Communications and Information Technology launched the 'Next tech leaders' programme, from which 5,000 people have already graduated. Similar initiatives taking place in Jordan, Saudi Arabia and the United Arab Emirates ultimately will lead to an increasingly skilled workforce starting and working in new competitive enterprises, as was the case in the United States of America and South Korea during the past 10 years, when more than 50 per cent of jobs were created by high-growth start-up companies.

Innovation and entrepreneurship are becoming the preferred pathway for many young people. In several Arab countries, a similar dynamic is playing out, where many recent college graduates would rather find private-sector employment or start an innovative enterprise rather than work for the Government. The past 10 years of innovation and entrepreneurship programmes in several Arab countries are starting to produce results; Lebanon ranked first worldwide for entrepreneurship impact on innovation and eighth worldwide for total early stage entrepreneurial activity, according to the *Global Entrepreneurship Monitor (GEM) 2016/2017 Global Report*.[9] Many Arab cities are not much different from most counterparts elsewhere in striving to be the next Silicon Valley, however unlikely that might be. Cities including Abu Dhabi, Doha, Dubai, Jeddah, Manama and Muscat have positioned themselves as candidates for the 'Silicon Oasis'. Amman, Beirut, Cairo, Casablanca and Tunis are carving competitive technology niches. That is not surprising, given that talented individuals globally seek cities that are technology friendly and teeming with technology entrepreneurs. According to a 2017 InterNations report, Manama ranked first, Muscat twelfth, Abu Dhabi fifteenth and Dubai seventeenth among the top 27 cities around the world where expats are happy, rents are affordable and jobs are plentiful.[10] So it is evident that many Arab countries and cities are not aliens to technology. Great potential lies ahead, although there are many challenges to overcome.

C. Can we afford ignorance?

As FTs transform economies and societies, they can also be agents of change, promoting core development objectives. The promised benefits of technology coincide with potential threats that require effective government regulations and cooperative international multilateralism. The productivity gains expected from technology must be balanced with fair distribution of wealth, through

an inclusive participation at local society level. Indeed, technologies can exacerbate inequality between and within countries and open dangerous new frontiers for conflict.[11]

In addition to anticipated socioeconomic development pressures, some Arab countries are currently suffering conflicts and related effects. Technology and innovation can offer effective tools with multiplier socioeconomic and environmental impacts. The Arab World Online 2017 report, based on a survey of 22 Arab countries, showed that about 71 per cent of Internet users in the Arab region are concerned that AI could result in privacy infringement, and 46 per cent are worried that AI could cause loss of jobs.[12] It is important to realize the complementarity of humans and machines to redefine intelligence as augmented rather than fully artificial. AI detects patterns and creates predictions, but it cannot yet replicate social or general intelligence, creativity, or human judgment.[13] Also, predicted smart processor and machine takeover of human workers is not equally distributed across professions and activities. While less than 5 per cent of all occupations can be automated entirely using demonstrated technologies, about 60 per cent of all occupations comprise at least 30 per cent of constituent activities that could be automated.[14]

Technology can be an enabler, a facilitator, a voice and a platform. It can reveal efficiency levers required to boost productivity and resilience. That is particularly valuable for reconstruction and recovery; inclusive governance and reconciliation; refugee return and rehabilitation; job creation and retraining, especially for women and young people in general; water, energy and food security; tolerance and equality; and digital economies, societies and government.

D. Defensive mode

Technology is a tool that people can use to facilitate and manage change and, in turn, using new technology can lead to enormous changes in human behaviour. As Arab countries ponder the implications of change, policymakers must definitely take it into account. For example, social media is a quicker way to share photographs than photo albums, but it is also a quicker way to recruit unknowing victims for criminal and terrorist activities. Policymakers and community leaders should start with the premise that technology is a tool that will be utilised by every sector. Like any tool, it must be introduced correctly through proper means.

The rapid take up of mobile phones provides an important case study in the role of Governments to manage innovation – or completely miss it. The adoption lag, or the average time it takes poor countries to adopt a technology, has shortened from 100 years in 1779 to just 13 years with mobile phones.[15] In addition, the nature of the adoption could not have been predicted. When Governments began approving mobile phones, they focused on the phone, rather than the other useful functions, such as location services. Governments did not foresee that the Internet or social media would become the primary use of mobile phones. However, the established benefits of today's proven technologies surpass productivity and efficiency gains expected, to change societal and economic landscapes into a borderless world. For example, social media platforms and crowd data sourcing have disrupted many industries, including marketing, commerce, advertising, journalism, hospitality, transportation and politics.

Other new technologies have bolstered conflict prevention and facilitated humanitarian missions, including connectedness, information access, jobs, markets, instant water filters, refugee identification, tracking, payments and remote health care. With nearly all technologies and innovations, negative consequences are possible. We are seeing such negative consequences with the use of social media as a means of incitement, the collection of private information on citizens, the spread of false information, the management of criminal schemes and the recruitment of terrorists. As Governments plan technological development and transfer for their countries, they must address the potential negative implications of technology and innovation in a proactive fashion.

The Arab region stands to benefit greatly from technological change, because the cost of new technology decreases with each advance, giving new entrants a late-mover advantage. That advantage, however, can undermine businesses that are labour intensive and, therefore, affect the employment and livelihoods of the unprepared. Technological change will benefit mainly countries that can leverage workforce skills and innovation

potential. Capacity-building and education should focus on technical training, in addition to scientific pursuits. Schools and universities can help to nurture innovation and cultivate entrepreneurship skills by teaching analytical skills and providing hands-on technical knowledge to better utilise FTs.

Technology and innovation will transform every facet of life in the Arab region. For post-conflict countries, technology provides opportunities for empowerment, access to information, reconstruction, industrialization and economic opportunity. Technology and innovation, used properly, can provide a means to rebuild countries using modern tools, such as 4G networks, nanotechnologies and remote-sensing technologies, in order to catch up with the rest of the world. Technology and innovation can also provide sustainability tools, an example being water-efficient seed varieties that can prevent overreliance on underground water sources or prevent desertification.

In the oil-rich countries of the Gulf, technology will help to make key industries more efficient and to diversify economies. In non-oil producing countries, there is an opportunity to create technology clusters that can leverage local workforce skills. Countries can take advantage of their relative proximity to Europe and Asia to become destinations for technology investment in science parks, information technology (IT) start-ups and local call centres.

In the Arab region, becoming more innovative will pay off. Innovation involves making a greater investment in research and development (R&D) by Arab Governments and private companies, and providing the capital to invest in emerging technologies. Combined with a trained workforce, innovative technology and new business models can create more vibrant economies and active societies, using localized technological solutions.

Despite experiencing more than 10 years of 'invading' technology such as drones, and with Egypt having very recently issued regulations on the use and commercialization of drones,[16] the Arab region has not applied at scale imported technology for security, medical, agricultural or other uses. Ten Arab countries have no policies on importing, using, or developing such technology. Similarly, despite the wide interest in AI, so far three countries in the region have formal national initiatives for AI (Egypt, Saudi Arabia and the United Arab Emirates), and only the United Arab Emirates has a national strategy. Arab policymakers should be more proactive in facing challenges rather than operating in a defensive mode.

E. Engagement mode

From AI and biotechnologies to 3D printers, FTs are delivering multidisciplinary solutions and possibilities that were science fiction only 20 years ago. However, the human role remains critical in selective interaction with, and integration of, smart machines. Studying and developing machine intelligence can help us to better understand and appreciate human intelligence.[17]

Arab countries have many new opportunities. The new environment challenges policymakers to ensure that planning takes into account changing technologies, without trying to forecast the future winners. Since the mid-1990s, an increasing number of initiatives to promote science, technology and innovation (STI) have been established, including technology parks and incubators. Initially, the focus was disproportionately on real estate. It is now moving towards a model more akin to innovation centres, often along the lines of a campus model where people can communicate and cooperate more directly. Technology parks have allowed the region to make progress not only in information and communications technology (ICT), but also in biotechnology, nanotechnology, space technology and green technologies. A growing number of Arab initiatives aim to encourage development in technology clusters. It is one of the priority areas for cooperation under the new Arab strategy for scientific research, technology and innovation,[18] the Network for Expansion of Convergent Technologies in the Arab Region proposed by the United Nations Educational, Scientific and Cultural Organization (UNESCO),[19] and the Arab initiative on nanotechnology.[20]

There is clear political will to transform the consumption-dominated economies of Arab countries into productive players in global value chains. More is required in terms of aligning efforts and optimizing processes. The ability of Arab countries to achieve sustainable development is

largely defined by their capacity to develop, adapt, manage and transform the most promising technologies for optimization and productivity in a multisector context.

For Arab countries to maximize the impact of technology on society in a positive and productive manner, they must view innovation as a series of four transitional steps to be undertaken by the national institutions of each country separately. It is through these steps that societies can best manage the impact of innovation and technology to make them helpful and positive, rather than negative or harmful. Most countries in the world are facing the same steps and challenges to manage the potential of technology for disruption.

The first step is to develop greater knowledge and understanding of FTs and innovations in order to stay ahead from a policy perspective during the current period of great innovation driven by the expanding capabilities of computing technology and its effects on the growth of the Internet, mobile communication, big data and critical sectors such as health care, life sciences, agriculture, water and energy. The recent price fluctuations of bitcoin, based on blockchain technology, provide a stark example of the challenges facing Governments, most of which stand by while the market goes up and down in a highly volatile way.

Box 1. Steps for innovation transformation in the Arab region

1. Understand the nature of frontier technologies (FTs) and innovations.
2. Improve capacities to localize, develop and apply new technologies and innovations.
3. Prepare society for new innovations in order to manage technological impacts.
4. Improve infrastructure, policies and frameworks in order to maximize technology's good impacts on society.

Source: Authors.

The second step is to prepare society to utilise new innovations and technologies. For example, we know that the Internet is changing how people learn. The education sector must provide more technical education. The South Korean experience is worth noting in this case.[21] The adult workforce must be given retraining opportunities; even adults must be prepared to retrain every few years so that they can continue careers as industries become disrupted.[22]

The third step is to organize society around new technologies, in order to manage technological impact in an optimal way. That is probably the hardest step in the process. It is relatively easy to understand technologies as new inputs to the education system. It is more difficult to change how society behaves. It is necessary to address issues of institutional processes and norms, as well as the regulatory and policy systems that manage technology and its applications. In health care, for example, the system must continually incorporate new drugs and other therapies. Genetic engineering and telemedicine will speed up that transformation.

The fourth step is to harness the power of government and trusted institutions to optimize the effectiveness with which technology and innovation are used. Institutions must address issues of access, price, security and appropriateness. They must prepare for the changes that innovation will bring to the existing status quo and stabilize the work environment as much as possible. Governments must make efforts to pre-empt brain drain. They must also assess the inclusion of innovation to benefit society and establish a mechanism to formulate policy. The Economic and Social Commission for Western Asia (ESCWA) has proposed an innovation policy framework for inclusive sustainable development in the Arab region, which can be viewed as such a mechanism.[23] It provides customisable guidelines for Governments to formulate effective innovation policies by focusing on elements such as vision and targets, national innovation systems and stakeholders.

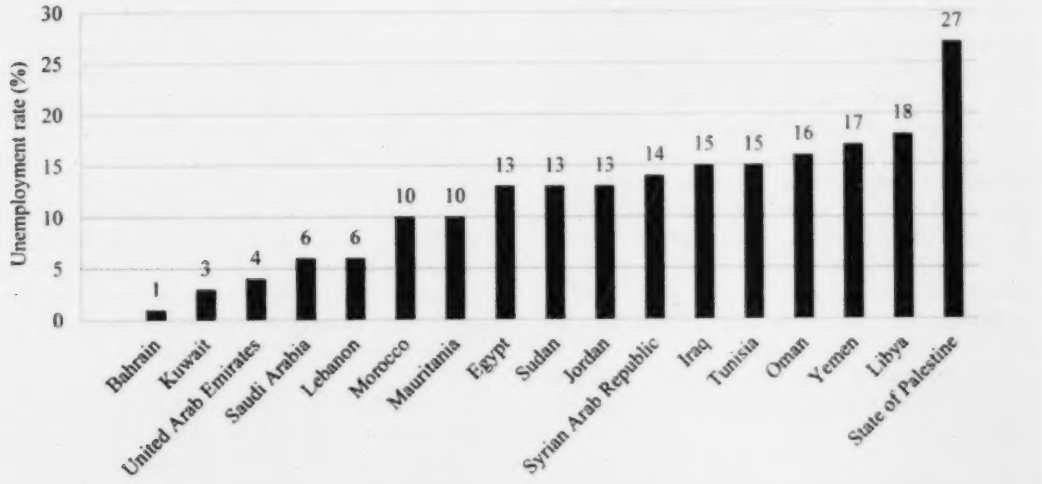
II. Augmented Vulnerabilities in Arab Countries

Challenges relating to sustainable development are associated with local contexts. The high population growth rate of Arab countries, combined with scarcity of resources and climate change implications, exacerbate the problems and add to the difficulties that policymakers face. The problems are further intensified by socioeconomic transformations and dynamics.

A. Frustrated youth: will technology provide hope?

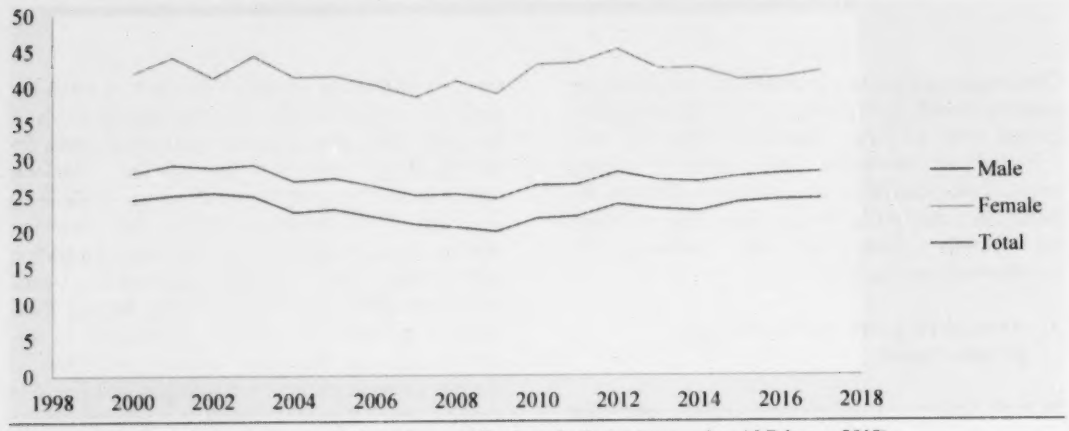
In most Arab countries, unemployment is prevalent not only among young men and women who did not complete their education but also among young people with high levels of educational attainment. Young women, in particular, are disproportionately affected throughout the region by an employment crisis, regardless of education levels. It is often the most educated groups that have the highest levels of unemployment, due to limited job opportunities for skilled labour, especially for women. Although people under the age of 30 years[24] comprise about 60 per cent of the Arab population, their potential remains severely untapped, causing much frustration and disillusionment. Education, regarded as a means of greater options and social mobility, has not lived up to its promise. The role of Governments in this context is to put their most creative and educated citizens to work on new technologies and possible applications.[25] Figure 1 shows the unemployment rates in Arab countries as of 2017. Figure 2 shows the proportion of youth unemployment in the region (using the age range of 15-24) between 2000 and 2016. A 2014 report by ESCWA indicated that 30 per cent of qualified youths are unemployed.[26]

Figure 1. Unemployment rates in selected Arab countries, 2017 (Percentage)



Source: Based on United Nations data. Available at http://data.un.org (accessed on 15 February2018).

Figure 2. Youth unemployment rate in the Arab region (Ages 15-24, percentage)



Source: Based on World Bank data. Available at data.worldbank.org/indicator (accessed on 15 February 2018).

To highlight the extent of overall unemployment in the region, it is possible to apply trend forecasting to a set of Arab countries to estimate the number of new jobs that would have to be created between 2017 and 2030 to reach a 5 per cent unemployment rate. For example, if Jordan replicated the current level of economic growth between 2017 and 2030, it would require the creation of almost 2.5 million new jobs, about 165,000 new jobs every year for the projected period, to reach a 5 per cent unemployment rate. Using the same projection criteria for Morocco, almost 6 million jobs would need to be created between 2017 and 2030. That would mean an annual increase of about 467,000 jobs, which is more than three times what the economy has been creating in recent years. Oman also would need to create more than 4.3 million jobs, which would mean an annual average increase of about 330,000 jobs, which is four times what the economy has been creating in recent years. Tunisia would need to create almost 8 million jobs between 2017 and 2030. That would require an annual average increase of some 570,000 jobs, which is eight times what the economy has been creating in recent years.

The problem is even more pronounced when youth unemployment is examined. An estimated 60 million young people of the Arab region will be looking for economic opportunities during the next 30 years.[27] That 'unemployment youth bulge' cannot be addressed without innovation, entrepreneurship and new industrial models. Without immediate prospects for durable solutions, many young people are at risk of entering and remaining in the precarious informal sector. Some could become victims or perpetrators of violence and illegal activities.

Government programmes and large industries cannot address the problem on their own. Innovation and entrepreneurship will be needed, at scale. The tech-savvy new generations are not interested in traditional educational curricula and methodologies. Exponential developments in technologies and related socioeconomic impacts necessitate a radical change in education and training at all levels. The worst reaction would be to maintain the status quo, without effective development policies in place. Digital and frontier technology awareness need to be instilled and skills taught to children from an early age, with higher education designed to equip school leavers and graduates with practical tools for work. Currently, the world's fastest job growth is in the area of data sciences and analytics, or big data.

FTs will automate jobs and replace workers, but new human tasks and vocations will be created. Human analytical and consultation roles will be required even as more tasks are done by robotics. That forecast, however, might apply only to the economies of the United States and similar countries, and not necessarily to Arab ones, which are characterized by different levels of development. That, in fact, could reverse the increasing trend of higher education unemployment in the region. Many skilled young men and women

leave the Arab region each year in search of better opportunities elsewhere. Development of sectors with FTs, along with appropriate market incentives, could attract talented expatriates back to the region, with the likelihood that they would help to further promote technological change. ESCWA promotes the entrepreneurship sector in the Arab region, especially among youth. That includes fields such as social entrepreneurship, which provides not only employment but the chance to contribute to inclusive sustainable development of communities and countries.

However, for entrepreneurship to flourish in the Arab region, an entrepreneurial ecosystem must be created and maintained to support people who wish to start their own enterprises or boost private sector development and productivity.

In addition, ESCWA and its sister United Nations agencies in the Arab region encourage educational reforms that equip children, youth and, indeed, all age or social groups with the skills required by the modern economy. Ensuring decent training and employment opportunities remains a priority. For entrepreneurship to flourish, Governments and the private sector should extend financial and technical support to young men and women.

B. Excluded women: can technology facilitate empowerment?

Although women in the Arab region have made significant progress during the past 50 years, there remain many barriers to their advancement. In areas of the Arab region where women are less likely to travel to meetings, community events or for work or school, the Internet is the great equalizer. In many areas, women do not visit physicians and hospitals with the regularity that they should. The web, while not always providing accurate information, can be supportive. For health-care professionals, it can provide a way to reach their female patients, who might not be able to visit them as much as they should. Digital technology is important in terms of educating women, not just about their health and well-being. Social media can be the means by which women become aware of the work of others, the manner in which different families are addressing social challenges, and to find information about events and activities. In more liberal parts of the Arab region, ICT becomes a tool by which women can further their networks, education and activities.

Digital technology can be an important tool in keeping women safe and secure. The combination of mobile technologies such as Facetime, along with global positioning systems (GPS) and apps developed for women to share their locations and call for help, are making it easier for women to leave their homes for errands, school or work. Police, law enforcement, women's groups and family members can use the technology to ensure that women are safe. Digital technology will, for those reasons, continue to create a sense of community and inclusion for women in the Arab region. Even more critically, technology, ICT in particular, can empower women at war or women refugees and their children.

In some Arab countries, digital technology is also likely to become an important tool with regard to political activism and education for women. Digital technology remains a relatively private, discreet means by which to communicate information about rights, political positions and human rights. Technology enables people to improve their quality of life and purchasing power. It can play several important roles in advancing gender equality in the region, and in connecting and empowering women.

C. Populations suffering from conflict: what relief can technology offer?

Many Arab countries are striving to resolve devastating conflicts, internal and external. Libya, the Syrian Arab Republic and Yemen are particularly badly affected at the moment. Other countries, including Iraq and the Sudan, are embarking on recovery from internal conflicts. Palestine remains under occupation, enduring discriminatory and illegal Israeli policies and practices, as well as the denial of millions of refugees in the diaspora their right to return.

The impact of conflict spills over to neighbouring countries, with Egypt, Jordan, Lebanon and Tunisia bearing the brunt of spillover effects. These include hosting millions of refugees, inevitably resulting in devastating social and economic consequences for the host countries.

Technologies can support conflict prevention and peacebuilding. They can enhance existing, traditional conflict-prevention frameworks and tools, for example by incorporating mobile technology for early warning and early response, and by mapping geospatial data for early

humanitarian interventions. Governments and international organizations are already deploying such innovations. Big data is being used to analyse and better understand group dynamics and affiliations in different conflicts. Software has been developed for facilitating mediation, and digital communication tools are being used to initiate contact and dialogue between groups and stakeholders that might otherwise not interact.

Other technological advancements can help to mitigate the humanitarian crises that result from conflict, including the refugees and internally displaced persons (IDPs) who flee conflict areas. Communication technologies, as well as data-gathering and analysis technologies, can assist in providing more coordinated and targeted relief efforts. In the longer term, new technologies can provide tools to facilitate the return of refugees as well as the rehabilitation and reconciliation processes needed in affected communities.

D. Persons with disabilities: can technological access barriers be overcome?

Persons with disabilities in the Arab region form one of the most marginalized and excluded population groups. They are often not visible in public life, because social and physical environments are inaccessible. They are disproportionally affected by crises and disasters. Their levels of educational attainment and employment are generally much lower than those of persons without disabilities.[28] This situation is perpetuated and aggravated by environmental and social barriers, discriminatory attitudes and inaccessible facilities. Access to social protection by persons with disabilities is often restricted by lack of information and laborious application procedures. The Convention on the Rights of Persons with Disabilities is the first human rights treaty to explicitly address the right of persons with disabilities to accessible ICTs, including in emergency situations. Accessible ICTs allow persons with disabilities to seek, receive and impart information. ICTs decrease discrimination, improve equality and social inclusion, and help persons with disabilities to achieve full enjoyment of their human rights.

Technological solutions have a large and increasing role to play in ensuring the rights of persons with disabilities to participate fully in society. Technological innovations are being used to enhance the accessibility of social protection for persons with disabilities, for example, through disability accessible websites and unified beneficiary databases. Other innovations, such as stair-climbing wheelchairs, digital Braille readers, communication devices controlled by eye movement and robotic prosthetics, can assist persons with disabilities to improve their quality of life and functioning and to overcome many of the barriers that prevent them from studying or working. However, it is important that such innovations be available and affordable, and that the environment be adapted to their use. Persons with disabilities are a heterogeneous group facing different obstacles, so technological solutions for some might be of little benefit for others. Persons with disabilities themselves have an important role to play, because they are the ones who best understand their own needs and how barriers can be overcome.

E. Impoverished populations: can innovation and entrepreneurship help?

In many Arab countries, a significant proportion of the population lives below the national income poverty line, as compared to the international extreme poverty line, based on purchasing power parity (PPP). According to the 2017 Arab Multidimensional Poverty Report, 40.6 per cent of the population in the 10 countries covered are multidimensionally poor – that is, deprived from access to health and education services, from adequate nutrition, and from assets including information, mobility and livelihood.[29] Arab countries can use technology to tackle extreme poverty and to address poverty more broadly in societies.

Technology can help reaching out to the poor through the design of appropriate policy and programme tools. That could include developing and analysing big data, administrative databases, and early warning systems. It could include devising technology platforms to support decision makers by increasing awareness, monitoring and enhancing coherence of policies to reduce poverty; improving access to technology, and the availability and quality of education and health services; and enhancing quality of governance, transparency and efficiency of public spending on poverty reduction. Arab countries can benefit from digital technologies, the Internet and the web in order to build applications and provide education relevant to their citizens in their local dialects, and also invest

in sustainable agriculture and water efficiency technology to provide for basic needs. Technology can be used for more efficiency in managing water, land and energy resources.

The promotion of community-based innovation practices, where a specific community or people in a broader community (rural or urban) come together to solve local challenges from a local perspective can also aid in the fight against poverty and the achievement of sustainable development at local level. There are several tools and techniques that communities can employ to enhance their social, economic and environmental well-being, such as grassroots innovation, social innovation and crowd-sourcing innovation. In some cases, successful community-based innovation initiatives can be up-scaled or transferred to other communities, allowing for a broader impact.[30]

F. Exhausted natural resources: are innovative technologies the answer?

Potable water, clean energy and food security are universally accepted as priority areas that must be planned and managed in a nexus approach. In addition, land degradation exacerbated by climate change in Arab countries must be addressed. That issue was highlighted in global climate modelling results and was mapped in the Regional Initiative for the Assessment of the Impact of Climate Change on Water Resources and Socio-economic Vulnerability in the Arab Region (RICCAR), a collaborative regional initiative led by ESCWA and the League of Arab States.[31]

The main technology clusters crucial for SDGs will affect resource management and are likely to involve many disciplines, including nanotechnology, ICTs, biotechnology, AI and big data. Digital tools to alter human behaviour are likely to be critical. In the corporate sector, there are systems of smart grids that integrate available information in order to improve efficiency. There are also significant worldwide innovations in terms of producing potable water. New chemical treatments are improving water for human use and for cleaning up previously polluted sources of water. Water filters are being developed at low cost for emerging markets. The filters improve home and community water usage, through simple, low-tech solutions such as rainwater harvesting. Some countries have invested in water desalination technologies to increase access to potable water at reduced cost.

Innovations in clean energy and alternative sources of energy are growing, reducing reliance upon fossil fuels. Such innovations include solar, wind, geothermal and hydropower. Project Sunroof by Google is connecting individuals with alternate energy providers by sharing how much sunlight falls on their homes and calculating the costs of conversion to solar power, thereby launching the conversation between solar services providers and consumers.[32] Natural resources management tools will also have a significant impact. They include the use of technology to track wildlife and natural disasters, and drones to manage resources remotely. Harnessing ICTs, geospatial information and other FTs is one of the agenda items in the United Nations Sendai Framework for Disaster Risk Reduction 2015-2030.[33] Technology is supporting the nexus approach in planning and managing water, energy and food.

G. Hackable everything: which dilemmas can technology resolve?

The information society, the knowledge economy, smart cities and the Internet of Everything create a constant invisible threat to everything digitized and connected. The anxiety is global. According to PricewaterhouseCoopers, Arab countries suffer 6 per cent more cyberattacks than the rest of the world.[34] That has led to greater local investment in cybersecurity technology. A concerted effort to understand the underlying technology, its implications in the long and short terms and how to customize it for local communities, is critical.

The various exponential technologies can be misused and might expose societies to unexpected threats and risks. The first step in fighting the dark side of technology is to identify weaknesses and potential areas for abuse. Defences against abuse can be legislative, regulatory, technological, educational, deterrence and elimination of possible risks.

Many Arab countries developed cybersecurity laws and regulations during the past decade. However, this is a dynamic area with evolving threats that needs continuous improvement. A few countries established dedicated centres to deal with the threats. Vulnerability to hacking is terrifying, from individual bank or other accounts to national projects.

Table 1. Threats by crucial emerging technologies

Cluster	Crucial emerging technology	Possible threats
Biotech	Biotechnology and proteomics; genomics; gene-editing technologies and custom-designed DNA sequences; genetically modified organisms; stem cells and human engineering; bio-catalysis; synthetic biology; sustainable agriculture; Mass-customisation of pharmaceuticals.	Military use; irreversible changes to health and environment.
Digital	Big data and data mining; IoT; AI and networked tools and appliances; distributed and 'cloud' computing; open data and open-source development; data sharing and online learning; mobile telephony; 3-D printing/additive manufacturing; micro-simulation; e-distribution; integrated data acquisition and remote sensing systems; virtual reality and telepresence; smart power grid; digital monitoring and security.	Unequal benefits, job losses, skills gaps, social impacts, poor people priced out; global value chain disruption; concerns about privacy, freedom and development; fraud, theft, cyberattacks.
Nanotech	Nano-imprint lithography; applications for decentralised water and wastewater treatment; desalination; solar energy (nanomaterial solar cells); artificial photosynthesis; organic and inorganic nanomaterials, metamaterials; memory alloys; enhanced resource extraction and waste treatment.	Human health (toxicity), environmental impact (nanowaste).
Neurotech	Digital automation, including autonomous vehicles (driverless cars and drones); robotics; smart technologies; cognitive computing; e-discovery platforms, personalisation algorithms, enhanced artificial intelligence and machine learning; handicap mitigation; brain-machine interface; augmented reality.	Unequal benefits, de-skilling, job losses and polarisation; widening technology gaps; military use; conflicts; hacking.
Green tech	Circular economy: technologies for remanufacturing, technologies for product life-cycle extension, recycling; multifunctional infrastructures; CO_2 mitigation technologies; low energy and emission technology. **Energy**: off-grid electricity systems, mini-grids, and smart grids; energy storage; heat pumps; enhanced energy recovery; biofuel supply chains; renewable energy systems; energy efficiency devices. **Transport**: integrated public transport infrastructure; energy efficient vehicles. **Water:** water and wastewater management technology; advanced metering. **Buildings**: sustainable/smart buildings, passive heating/cooling. **Agriculture**: Sustainable agriculture; hydroponics; bio-based products and processing; low-input processing and storage; horticulture techniques; efficient irrigation; application of biotech.	New inequalities, job losses; concerns about privacy, freedom and development. Public health.

Source: Based on United Nations, Department of Economic and Social Affairs, *Global Sustainable Development Report 2016* (New York, July 2016), p. 53.

III. Development Priorities in Arab Countries

Policymakers should work on addressing the vulnerabilities described above. Given the scarce resources of many Arab countries, however, those vulnerabilities must be prioritized.

A. Decent employment

Decent employment is a priority with multiplier benefits not only for economic growth but also for social and political stability. One of the factors that spurred the Tunisian and Egyptian uprisings of 2011 was lack of job opportunities, especially for youth. In recent years, amid low oil prices, rising debt and conflict in several parts of the region, Governments have faced fiscal constraints, but the need to generate decent employment opportunities is more pressing than ever. Technology can support economic growth, but the region's precarious labour market, especially for young men and women, and women in general, requires rethinking industrial policies. Those policies need to address employment and economic challenges using technology that has the least disruptive effect on local labour markets.[35]

To create decent jobs, Arab countries can start by analysing the skill sets of their current working-age populations. The next steps would be to determine how many people could be reskilled; the types of schemes that could harness and improve youth productivity; and the skills most in demand. In East Asia, Europe, India and North America, for example, the job category of data scientist is constantly among the top five job-growth categories.[36] That might well be the case in the near future for Arab countries as well, especially with the steady growth of digital Arabic content on the Internet. Certainly, the region will see the impact of data analytics, but whether those jobs will be based in the region is unclear.

Another common challenge is the mismatch between where jobs are available and where job seekers live. The discrepancy is more pronounced in Arab countries of the Maghreb and the Mashreq. For example, Egypt has the largest pool of engineers and scientists in the Arab region, but many of the job opportunities for engineers and scientists are in Gulf countries and are related to oil and gas, logistics or infrastructure. In many sectors, technology solves the mismatch by allowing people to work remotely via email, web communication such as Skype, and other over the top technology (OTT). Technology tools have also created job opportunities for previously impoverished communities. Millions of entrepreneurs work globally using the Internet and their smart phones. Such platforms as Instagram and Facebook have become an important channel for sales and marketing, even among the wealthy. Restaurants, caterers and event specialists are running their marketing, logistics and payment through the Internet.

New types of financing, including social finance and Fintech, are making it easier for entrepreneurs to access capital using the Internet, thus unlocking capital. In the world's emerging markets, entrepreneurship has been embraced as a necessity. The global scale of emerging markets is another major driver. There is strong evidence from other world regions that innovation and entrepreneurship can be a promising means by which jobs can be created at scale. Entrepreneurial activity can generate spillover effects on national employment, in addition to social and cultural impacts. Not all entrepreneurial activities are the same: they range from self-employed subsistence entrepreneurs and their micro-businesses, to social entrepreneurs, who mostly create value for others.

In Arab countries, entrepreneurial activity appears robust, with about 13 per cent of the working population engaged, which is far higher than in Japan, Germany, or the United States. However, most of the entrepreneurs are subsistence entrepreneurs with very small-scale businesses. About 80 per cent of businesses appear to be established out of necessity, generally employ family members and are valued at less than $15,000 each. In aggregate, they do, however, create significant value, as their overall share of the economy is often significant. They generate a large proportion of private-sector employment in various countries, from Morocco (65 per cent) to Saudi Arabia (40 per cent).

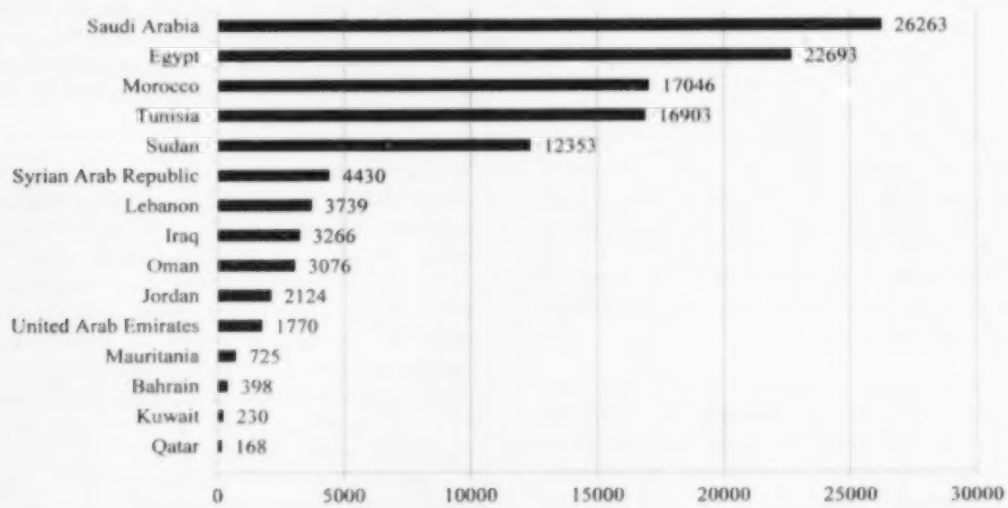
However, technology entrepreneurship in the Arab region is still heavily dependent on capital raised in the West, or from the Arab diaspora with international experience in places like Silicon Valley, Boston, New York or London. It is important to enlist Arab region sovereign wealth funds for investing in local start-ups rather than in more developed countries. The rise of crowd funding can be an important opportunity for technology entrepreneurship in the Arab region. There are several countries in the region whose citizens have significant resources. A regional plan to formalize crowd funding for start-ups serving the Arab region, whereby investors from across national boundaries could invest in regional start-ups, would unlock hundreds of millions of dollars in private capital that would go directly to start-up ideas from emerging markets like Jordan to large countries like Egypt and Saudi Arabia, resulting in decent employment of educated generations and creating crucial multiplier effects in local communities.

The formal education sector, serving students aged 3 to 25, needs to play its role in helping to equip future workers with the required skills, and in collaborating with industries to ensure the refinement and application of those skills. Three important steps are required during the next 10 years.

First, develop strong and dynamic curricula to teach new ICT skills. Suitable programming languages can be taught at an early age to prepare children either for careers in coding or the ability to use code in other occupations.

Second, implement internship and experiential learning programmes with industry, because schools and universities are likely to need help in developing curricula as quickly as technology evolves. Such approaches have been used for decades in North America and Europe, connecting students and teachers/faculty with latest technologies used in the workplace. Governments need to promote such programmes using their power to bring together large companies that are local or international, doing business in their countries, with large universities and schooling systems. As FTs are based on scientific analysis and mathematical algorithms, education in science, technology, engineering and math (STEM) becomes critical for countries to maximize the benefits from the use of advanced applications. In many Arab countries, STEM graduates compose a sizable group in society, as shown in figure 3, and must be deployed optimally in the research, development and innovation cycle.

Figure 3. Numbers of STEM college graduates in selected Arab countries



Source: Based on data from the UNESCO Institute of Statistics. Available at http://data.un.org (accessed on 15 February 2018).

Note: Numbers represent the latest available data for each country and go back to the period 2014-2015.

Third, local and multinational companies in Arab countries must accept a much larger role in training the regional workforce. The role of companies must go beyond corporate social responsibility to share community-building values and be part of a broader strategy to retrain the adult workforce. In several countries, a large proportion of college graduates are being underutilised. These adults must also be retrained to use new technology, whether in Java and other technical coding languages, or call-centre software operation and social media for marketers. Philanthropy and socially responsible investing can create positive benefits for society, in addition to profits for businesses.

B. Economic transformation

The region needs transformational changes from the current way of doing business, in order to overcome the low-productivity trap across economic activities that are largely informal;[37] to generate millions of new employment opportunities for youth; and to improve labour's share of income so as to reduce poverty. Technology and innovation can provide creative solutions, within a well-designed framework of industrial policy that promotes structural transformation and productive employment, and also minimizes technology's disruptive negative effects.

Certain digital technologies can be transformative, bringing with them more growth and new employment opportunities. As in other parts of the world, Arab countries can become centres of high-growth start-up jobs. Several Arab countries are focusing on higher added-value technology entrepreneurship as old development models become outdated. Many entrepreneurs seek to launch technology companies, innovate in new industries, and leverage the existing capital of the region and large markets to support a vibrant Arab digital economy. The digital economy[38] is today characterized by new technologies practically unknown at the time the concept was introduced, including fixed broadband access reaching tens of megabits per second, mobile broadband, smartphones and their apps, interactive websites, social networks, sharing platforms, cloud computing, and the Internet of Things (IoT). All that is becoming a reality in most developed and developing countries, affecting their growth and development potential.

The digital economy is currently high on the agenda of public policy debates in many countries, primarily among developed ones.[39] That interest stems from two main factors. The first factor is the tremendous growth of digital technologies, with nearly half the world's population accessing the Internet, and 80 per cent of citizens in country members of the Organisation for Economic Co-operation and Development (OECD) accessing fixed and/or mobile broadband connections. The second, equally important, factor is the fact that these technologies permeate the world economy from retail (e-commerce) to transportation (automated vehicles), education (massive open online courses), health (electronic records and personalized medicine), social interactions and personal relationships (social networks).[40]

For Arab countries to embrace and modernize with FTs, they will need to make reforms and invest resources in the following areas.

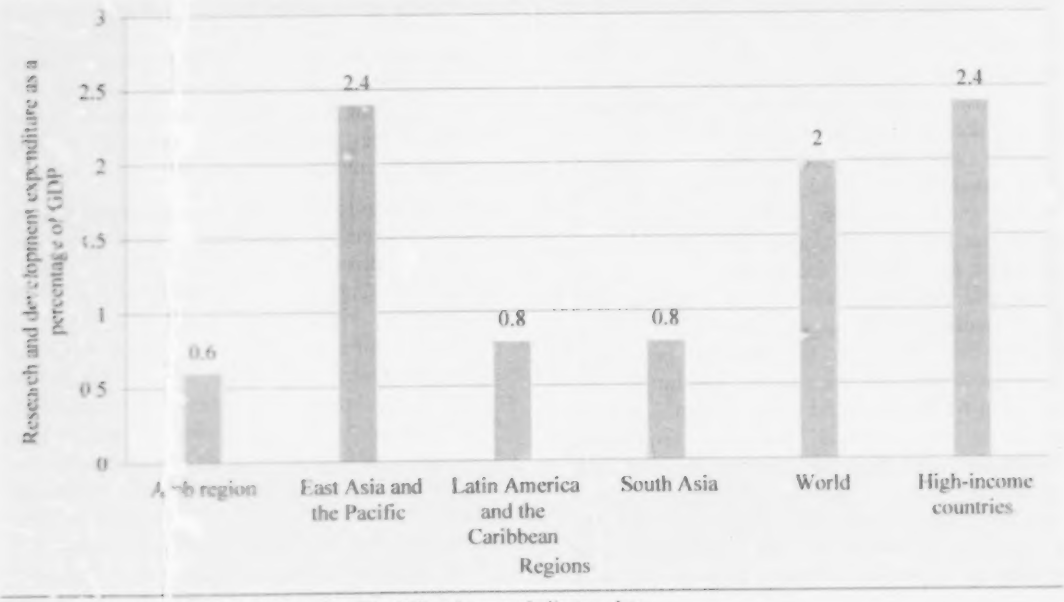
- **Research and development (R&D).** National and regional R&D is low, a large part of it being spent on research collaboration with Western institutions. Arab countries spend an average of 0.6 per cent of their GDP on R&D, compared with about 2-3 per cent for other regions that have led industrialization in recent years.[41] It is critical to engage local private sector in R&D activities with governmental incentives not based on tax exemption only. More relevant programmes are needed that address the concerns of local industry, linking it to the knowledge producers in universities and research centres.
- **Encouraging relatively high labour-intensive modern sectors.** Some digital technologies can be disruptive and labour displacing, which affects patterns of productivity and competitiveness. The size, direction and distribution of the effects are a matter of debate, as are policy options for steering the digital revolution in a socially desirable direction. One of the key issues for the region in adopting technology is to identify its strong potential to generate decent work along with increasing productivity, including in higher-end modern services that are relatively labour-intensive in the regional context. Redesigning industrial policies by taking into consideration the specific

labour-market features of the region as well as energy use, competition, innovations and labour share of income, can bring transformative changes to the economy and society.[42]

- **Increasing access to capital**. Many countries in the region have investment funds, but they tend to invest or lend money in a way that is risk free and driven by securities. Investors and Governments must take a much broader approach to investment as a means of economic development rather than maximum financial return. Government fiscal policies need to show the way by investing in innovation, human capital and infrastructure that contribute to technological development and economic transformation
- **Securing foreign direct investment (FDI) for technology development.** The size of the Arab region makes it a potentially lucrative area for technology development. And yet, without FDI, local affiliates of international organizations and local start-ups often have difficulties securing the strategic investment partners they need to succeed. Mauritania, the Sudan and Yemen might want to approach the newly formed United Nations Technology Bank for Least Developed Countries hosted by Turkey.
- **Adjusting trade and competitiveness policy in the region.** One of the biggest regional challenges facing international companies is navigating the rules of Arab countries. It is important to simplify and stabilize legislation and procedures for business development and trade, making such legislation and procedures easier for technology ventures and interchanges.

The development of stronger industry in the region would lead to a positive impact on social issues because a greater percentage of the workforce would be gainfully employed and more productive members of society. Social sectors such as education and health care are where the greatest impacts can be expected. Innovations in agriculture and sustainable food security systems, including farming, supply chain, packaging and nutritional content, will have a transformative effect on the health of the people in the Arab region.

Figure 4. Shares of expenditure on R&D as a percentage of GDP in world regions, 2011



Source: E/ESCWA/GDID/2017/4, based on World Development Indicators data.

As Governments in the region continue to devise policies and programmes to promote technology for development, a key for collaboration will be to emphasize technology opportunities that are common throughout the region. At first glance, it is hard to see where a post-conflict society could have much in common with a Gulf oil producer. And yet, finding common areas creates pressure for change and motivation in terms of resolving issues and identifying several areas where a common vision can be created. Such areas include the following.

- **Scaling up local start-ups to create content related to preserving and promoting Arab culture, language and arts**. Most of the content being created in the Arab region, for Arab populations, remains in the realm of international companies. While Arabic digital content is now the fourth largest in the world, it remains on the sites of American companies such as Facebook, Google, Apple and Amazon. Indeed, the acquisition of Souq.com by Amazon for $580 million in 2017 was the largest acquisition of an Arab-launched technology company.[43] There is enormous opportunity in education, technical content, arts and marketing to use technology to create consumer businesses with digital Arabic content to reach the majority of Arab citizens. In addition, there is a chance to create local call centres and business operations that target Arab customers for the Fortune 1000 companies.

- **R&D and innovation to resolve public health crises around the region.** There is no question that health problems like diabetes, hypertension, high cholesterol and heart disease are common throughout the region to an alarming degree. A common agenda to fight those concerns, through research, government funding and a joint public health campaign using social media and technology, could have an enormous effect on quality of life.

- **Migration of talented workers**. A broader, pan-Arab approach to skilled labour migration would resolve the problem of finding talented workers in the region. Egypt, for example, had 700,000 engineers in 2016 according to the President of the Egyptian Engineers Syndicate,[44] while the Gulf countries had few of Arab origin. A better migration plan could match technical talent with growing technology companies.

- **Access to capital for good ideas and entrepreneurs.** Today, there is strong technology start-up national activity in Egypt, Jordan, Lebanon, Morocco, Saudi Arabia, Tunisia, Qatar, and the United Arab Emirates. And yet, there are constraints for investing capital in start-ups in other countries of the region. That is partially why those countries have not developed robust start-up environments. As STI cooperation can benefit all, addressing that challenge by finding ways to allow cross-border investment and crowdfunding for technology start-ups in the Arab region would unlock urgent capital for the region's technology community. The GCC countries have the ability to jump start their own innovation economies without relying on foreign direct investment. According to the Dubai based Research and Markets, there are 480,000 high-net-worth individuals with a combined wealth of $2.5 trillion living in Arab countries.[45] And yet, only $165 billion is tied up in venture capital firms and foundations, with the majority of capital likely to be allocated to non-regional venture capital funds and foundations. Finally, policymakers must recognize the gestation period between investing in R&D and reaping its benefits.

Advances in technology have opened new markets and new opportunities for progress in critical areas such as health, education, energy, economic inclusion, social welfare and the environment. GDP growth and related benefits are predictable responses to improved productivity. However, fair distribution of such growth in GDP to labour is necessary in order to avoid increased inequality. It is critical to diffuse as widely as possible the overall gains in opportunity and prosperity enabled by technology.[46] Emerging cities with strong leadership and more flexible regulatory frameworks could be prime partners for global companies and investors looking to demonstrate pioneering solutions.[47] As Arab countries develop strategies to use technology, it makes sense to start with affordable and optimized frontier technologies because, in most cases, there are no inherited legacy systems.

C. Recovery and reconstruction

Technologies are envisaged to provide enormous potential to support Governments of conflict-ridden countries in overcoming the challenges of

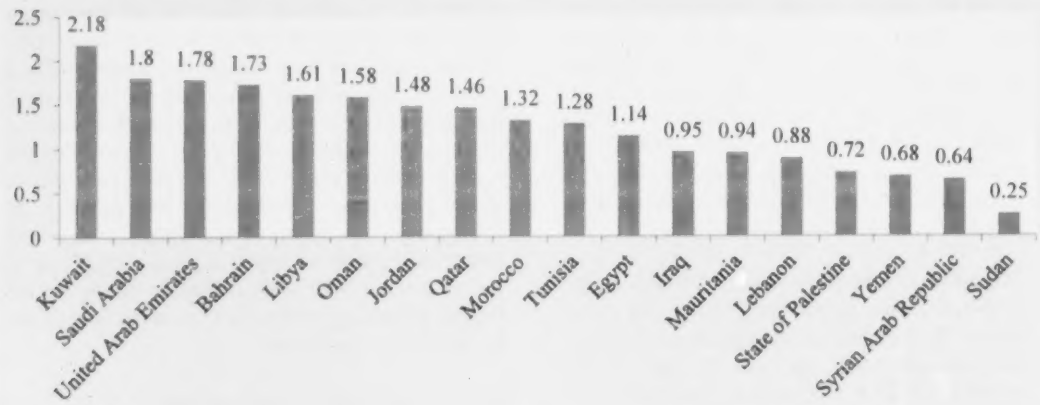
reconstruction. Many Arab countries will be reconstructing cities and villages and reinstating refugees after the conflicts have receded, starting with removing rubble to prepare the way for new infrastructure, energy and water networks. Health-care and education systems will need to be rebuilt. Efficiency is essential in harnessing political will and public enthusiasm before allocation of dwindling resources induces pessimism. The tragic legacy of war is a key constraint on post-war growth, especially through the damaged State institutions, commercial networks, the loss of trust and the weakening of market institutions.

Harnessing digital technologies and ICT during recovery and reconstruction has been essential in many past reconstruction situations, including Afghanistan and Liberia, according to a 2014 World Bank report.[48] The impact was seen from the early stages of reconstruction, including stabilization. It helped to facilitate social cohesion and connectivity after communities had been destroyed. It helped to retrieve or recreate educational and health records. It helped to make Governments and enterprises more productive and efficient. The application of technology enabled especially critical solutions during the phases of refugee return and reconstruction of the built environment.

For example, removing an estimated 10 million tons of debris to the outskirts of Mosul after its liberation will cost more than $250 million, according to a 2017 United Nations Environment Programme report.[49] Innovative recycling empowered by green and nanotechnologies of around 50 per cent on site inside the city can save 6 million trucking kilometres and a related 30 per cent in terms of costs and environmental impact. Affordable carbon-based filters inside water bottles remove organic contaminants from regular municipal tap water and support safe drinking at refugee camps and when the refugees return home. Abundant and affordable photovoltaic solar panels offer sustainable energy sources and facilitate health care, education and safe food storage. Solar cookers that are affordable and easily developed locally can provide safe and healthy cooking in a sustainable and green process. Geospatial technologies and artificial intelligence algorithms can manage migration flows. Blockchain systems have been tracking the educational records of refugees and subsidies by United Nations organizations.[50]

Most of the recovery and reconstruction efforts will require ICT infrastructure and appropriate content. According to an ESCWA Regional Profile of the Information Society, the average mobile phone penetration rate in the region reached 108.2 per cent in 2015, exceeding the global average of 96.8 per cent.[51] During the past 10 years, the rapid penetration of the mobile phone has been the greatest tool for development.[52]

Figure 5. Mobile adoption (Average connections per person)



Source: Based on data from the International Telecommunications Union. Available at https://www.itu.int/en/ITU-D/Statistics/Pages/default.aspx (accessed on 15 February 2018).

Technology offers effective tools for sustainable recovery. Customized innovative technology solutions can help to address priorities of early recovery, reconstruction of homes and infrastructure and community development.

D. Technology opportunities for sustainable development

The FTs are expected to consume resources responsibly, deliver expected performance effectively, empower people inclusively and reward investments generously, all of which would support sustainable development. However, markets in developing countries might choose to buy turnkey systems if they are struggling to absorb the new technologies, lacking adequate infrastructure and skilled talent.

The Arab region's comparative advantage is its existing energy sector. The field has a proven history of using STIs to deliver significant results, both upstream, in oil fields, and downstream, in chemical manufacturing. Thanks to heavy investments in R&D and innovation, producers have been able to significantly increase the recovery rates from existing oil reserves. The lessons learned and the technologies developed can now be used in a wider range of applications. The region's producers have traditionally marketed basic chemical products. They need to diversify from marketing such commodities towards more specialized products. The move downstream requires partnership with research centres. That would help to further develop regional STI ecosystems. The Arab region has a natural comparative advantage in sustainable energy, which is at the beginning stages, accounting for "6 per cent of the region's total power generation capacity, mostly in the form of hydropower (4.7 per cent), wind (0.9 per cent) and solar energy (0.4 per cent)" in 2015, based on a 2016 International Renewable Energy Agency (IRENA) report.[53] In addition, rural farmers are installing biochemical systems such as digesters that generate biogas and fertilizers. In some areas, such systems have been successfully expanded to use municipal waste.

Arab countries increasingly see alternative energy as another investment in a field in which they have significant expertise and connections. There are international precedents. For example, the state of Texas, viewed as an oil and gas industry stronghold, has become the largest producer of wind power in the United States, and one of the largest for solar power.[54]

Complex innovations are required for efficiency and sustainability in water and energy use, sanitation, supply chain, air pollution management and housing. In addition to smart devices that monitor consumption, new products must make water cleaner and homes more energy efficient by using better materials and wasting less. ESCWA implemented two related projects in Arab countries, one on strengthening national capacities in the ESCWA region on developing green production sectors 2012-2014, and another on building capacities in developing appropriate green technologies for improving the livelihood of rural communities in the ESCWA region.[55]

Big data can play an important role in improving farming by connecting farmers with information about every aspect of farming, including how to improve their yields and market conditions. Internet connectivity and social media can eliminate unnecessary fees by brokers to take crops to market. Through R&D in other parts of the world with similar climates, there have been breakthroughs in seeds that use significantly less water than traditionally, and methods of irrigation, such as next-generation drip irrigation.

The cluster around nanotechnology and material sciences has the most far-reaching implications. It affects many sectors, including energy, manufacturing, resource extraction, water and waste management. Biotechnology clusters are rapidly evolving around technologies such as proteomics, gene editing and genetic engineering. Other areas include biocatalysis, synthetic biology and sustainable agriculture technology. Biotechnology offers opportunities in SDG areas such as food crops and human health, but also affects other technology fields such as material sciences. Further developments in those sectors will help to develop a green technology cluster and a more circular economy. Resources would be optimally used and reused or repurposed with resource-efficient manufacturing and agriculture, and infrastructure would be integrated, with multimodal transportation systems.

An example of regional initiatives is the intended nationally determined contributions of Saudi

Arabia, the objective of which is to promote and encourage actions in the field of carbon capture and utilization/storage technologies.[56] The country plans to create the world's largest carbon capture and use industrial plants to capture and purify about 1,500 tons of carbon dioxide a day for use in other petrochemical plants, and to test its use in enhanced oil recovery, so as to assess the viability of greenhouse gas sequestration in oil reserves. The Arab region will selectively embrace industry 4.0 technologies according to local development priorities, absorption capacity and economic feasibility. Concurrently, it has an opportunity to develop responsible production processes and technologies in a way that enhances its competitive advantage. Those initiatives will support the implementation of regional commitments contained in the Paris Agreement on climate change.[57]

In a different field, digital health opportunities are using customized apps and wearables that can track patient health. There are initiatives being developed for the low-cost provision of health care, including diagnostics, subsidies for drugs to treat malaria, tuberculosis and HIV/AIDS, and the use of synthetic biology and therapeutics to treat difficult-to-reach populations.

Technology also creates applications that excite students about education. Digital learning is an important way to reach students in far-flung areas of the Arab region. That will be particularly important in post-conflict areas, but also in large countries like Algeria, Egypt, Morocco, Iraq and Saudi Arabia, where distances between villages and small cities can provide obstacles to educational attainment. Digital and online education cannot replace the classroom but can supplement it. According to UNESCO, only about 40 per cent of technical graduates of universities in the Arab region are qualified to work in their industries.[58] Online lifelong learning schemes can be a productive opportunity for matching graduates with locally needed skills.

Table 2 shows sample roles of technology in achieving SGDs in Arab countries. Some applications have already been implemented.

Table 2. Sample technology roles in SDG implementation in Arab countries

SDGs	Technology-related target numbers and potential contribution of technology for their fulfilment
Goal 1. End poverty in all its forms everywhere.	1.4 Develop digital Arabic content platforms that connect people to direct government programmes for easier services and direct-aid payment. Unleash enabling potential through affordable, secured communications and abundant connecting devices to multiply development opportunities and microfinancing for the poor, and empower refugees and war-torn communities.
Goal 2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.	2.3 & 2.A Improve limited arable land and low agricultural productivity in Arab countries by using green technologies and biotechnology to rationalize water systems, produce suitable seeds and safe, effective fertilizers. Digital platforms can give farmers direct open access to market information and weather forecasts, as well as technical advice adequate for their local needs and enquiries. Soil-less smart hydroponics and derivatives can produce needed food in desert countries with recycled water, efficient nutrients and limited space.
Goal 3. Ensure healthy lives and promote well-being for all at all ages.	3.3, 3.5, 3.8 & 3.D Digital Arabic content of portals and websites supports the dissemination of information related to health care especially in rural areas and for refugees and internally displaced persons. IoT and AI tools facilitate the practical collection and processing of data related to disease and illness. Smart phones and practical connectivity can facilitate low-cost diagnostics and provide remote health care, especially with cultural obstacles and financial limitations restricting proper health care in many communities, especially for women.

SDGs	Technology-related target numbers and potential contribution of technology for their fulfilment
Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.	4.1, 4.2, 4.3, 4.4 & 4.B International and regional online learning platforms can facilitate access to educational resources typically not present locally for many communities and age groups in Arab countries. Use of blockchain-based solutions can better track enrolment and progress at the individual, national and regional levels, especially among millions of people in Arab countries who have relocated, whether voluntarily or involuntarily.
Goal 5. Achieve gender equality and empower all women and girls.	5.B Access to technology, especially in terms of local context and language, can enhance gender equality and female empowerment, allowing women and girls to access information. Arab women's sustainable livelihoods can be enhanced through expanded access to knowledge, health services, markets, education, training and employment. Digital Arabic content and applications are helping women to become more active citizens.
Goal 6. Ensure availability and sustainable management of water and sanitation for all.	6.2, 6.3 & 6.4 Networked sensors and smart management will detect water distribution network leakages that remain unacceptably high in most Arab countries. Frontier technologies (nanotechnology) will enable efficient water desalination using a small fraction of energy currently used in regional industrial plants. Solutions based on biotechnology and nanotechnology will make water sources safe and sanitation more hygienic, especially in refugee camps and among devastated communities recovering from conflict.
Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all.	7.2, 7.3 & 7.A Fossil fuel remains a vital artery of the economic heart of Arab countries. It can become a cleaner energy source by using advanced material (nano and bio) technologies, smart production supervision and control. Smart grids, smart buildings and smart homes facilitate energy efficiency and lower energy consumption, especially in GCC countries. Green technologies harness renewable energy from the radiant global solar belt encircling Arab countries from Morocco to Iraq. Affordable photovoltaic solar panels can provide power for refugees and help to rebuild post-conflict communities.
Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.	8.2, 8.3, 8.5 & 8.6 Digital technologies will empower educated young people in identifying global innovation challenges and related economic opportunities. Digital technologies will increase fair and competitive markets driven mainly by added value. Frontier technologies and innovative ventures will improve the industrial productivity of abundant labour in Arab countries. ICT-enabled education will equip educated youth with relevant skills. Scientific discoveries and technological innovation layered on top of comparative advantages of available natural resources (including oil, gas and phosphate) in Arab countries will contribute added value to economic enterprises essential for Arab countries to enhance and diversify their economies.
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.	9.1, 9.4, 9.5 & 9.6 Arab young people can become technology entrepreneurs serving local digital content and priorities. ICT and social media platforms can help Arab countries to leverage the Arab diaspora economically and politically to create partnerships harnessing cultural and familial connections. AI and geospatial technologies can be used to develop evidence-based innovation policies for diversifying GCC economies and supporting the inclusive sustainable industrialization in other Arab countries.

SDGs	Technology-related target numbers and potential contribution of technology for their fulfilment
Goal 10. Reduce inequality within and among countries.	10.2, 10.3 & 10.10 Technologies enable information and knowledge to be accessed by all digitally connected countries and people. Local talented people have a chance at global markets and clients. Online training programmes equally offered to all countries can upgrade skills for youth and the elderly in new fields and technologies not yet available in Arab countries. Fintech solutions will provide financing services, especially for digital economy aspects still weak in many Arab countries (outside the GCC), such as reducing transaction costs of migrant remittances.
Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable.	11.3 Smart cities harness various digital technologies collecting and analysing data and identifying potential optimisation of traffic, security, water and energy consumption, along with effective urban planning.
Goal 12. Ensure sustainable consumption and production patterns.	12.2, 12.3, 12.5, 12.8, 12.9, 12.10 & 12.B Use smart packaging to avoid food waste and spoilage, especially in Arab countries that suffer frequent power interruptions. Use Arabic content on the Internet to educate citizens about health information, including making better choices regarding food and exercise. Integrate IoT sensors to connect devices, machines, vehicles, warehouses and other items to track efficiency and reduce energy use, especially after unexpected delays caused by conflicts and related security measures. Track the mobility of religious pilgrims using IoT wristbands, and monitor their survival needs.
Goal 13. Take urgent action to combat climate change and its impacts.	13.2, 13.3 & 13.5 Smart applications, particularly in the areas of energy, transport and building, manufacturing, smart services and agriculture and urbanization in general, can help to tackle climate change and mitigate its impacts, especially in vulnerable areas like the Nile basin and Oman hills. Digital technologies with Arabic content and local measurements are the main tools to improve advocacy, education, awareness of and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning.
Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.	14.4 & 14.A Satellite monitoring improves navigation safety and accountability, especially in oil-export critical Gulf and world trade Red Sea waterways and gates. Open source big data software and cheap sensor networks can be used to track possible oil spills and analyse biodiversity, pollution, weather patterns and ecosystem evolution, therefore helping plan mitigation and adaptation strategies.
Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.	15.3 & 15.5 Digital technologies such as available satellite imaging support prevention of further biodiversity loss, especially in arid zones encircling many Arab communities. Mediterranean southern rim developing cities need real-time data collection and subsequent waste management technologies for monitoring and processing increasing waste problems of all types. AI algorithms can learn behaviour and predict avoidable future damages through triggered action. Refugee reinstatement can enhance sustainable land ecosystems if IoT data are collected and used properly in public policy planning.
Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.	16.6 & 16.7 Digital technologies are powerful tools for humanitarian aid and peacebuilding in geographical areas responding to and recovering from conflict. The tools can help in areas such as disaster relief, aid management, electoral monitoring, open public data for transparency and stronger economic growth. Social media and other emerging ICT platforms facilitate interactions between government and citizens, allowing citizens to be involved in decision making and helping Arab Governments to respond constructively to popular opinion.

SDGs	Technology-related target numbers and potential contribution of technology for their fulfilment
Goal 17. Strengthen the means of implementation and revitalise the global partnership for sustainable development.	17.6, 17.7 & 17.8 Adequate technology transfer with multiplier effects on development and security priorities can provide the basis for more resilient societies in the region, using science, diplomacy and regional integration schemes. Financing the implementation of SDGs is possible using fintech applications in Islamic banking.

Source: Authors.

E. Robust States serving the people

The complex nature of technology's impact on every industry and economic sector requires government involvement to best prepare for the implications of that technology. Governments are considering digital technology for social stability and good governance. Public governance in the Arab region can deploy technology to address more public-sector transparency and accountability, and more effective participation of young people and women in public decision-making. With the necessary political will and a receptive social structure, technology can help to combat corruption and enhance the effectiveness of government processes at all levels and in all sectors, from collecting taxes to meeting infrastructure needs. For example, Governments can improve transparency across institutions by incorporating technologies that increase automation, simplification, efficiency and accuracy across government processes; by using anti-corruption software tools in e-governance and e-procurement practices to identify processes at risk of fraud or irregularities; and by dispatching mobile applications that allow citizens to report corruption.

Inclusive governance can be supported by technologies that provide platforms and tools enabling citizens from all walks of life to have more direct access to public institutions, processes and government officials; and to voice their opinions, mobilize and coordinate advocacy efforts. Thus, technology can serve as a catalyst for promoting wider engagement between government and societies, improving civil rights by facilitating the flow of information and enhancing the quality of public services. Technology however, can be a double-edged sword. Governments can acquire capacities that could be used to increase control over populations and limit freedoms, for example by regulating digital infrastructure, or utilizing universal surveillance programmes.

In the Arab region, using technology and innovation to gain promised multiplier effects for social good will not simply be about identifying new technologies and making them available; it will be about developing the capabilities in society to localize and build capacity around the new technologies. Another important component of the technology agenda will be promoting open government as much as possible. Achieving sustainable development is not only the responsibility of government; it should be shared by the whole society. The private sector, civil society and the general public cannot wait passively for a Government to deal with the above challenges. As members of society are affected by the challenges faced, they should actively participate in finding and implementing solutions, voicing their social, economic and political needs, and indicating what they regard as the most urgent.

Free and open collaboration between government at all levels and all sectors of society provides for strong institutions and a transparent and accountable public sector that succeeds in serving all its citizens. It is, therefore, necessary to move towards creating open government that allows for the free flow in both directions of information, knowledge and skills, as well as better collaboration and shared responsibility. By realizing the envisioned partnership through openness, it will be possible not only to achieve SDGs better, but also to create inclusive and equal societies that are better equipped to handle future developments.

Governments should also innovate to improve their products, services, policies, programmes and

processes. The objective of public sector innovation is to enhance the social welfare and economic growth of a country for a more sustainable future. There are a variety of public-sector innovation methodologies, including frugal innovation, bottom-up innovation, collaborative innovation, disruptive innovation and local innovation. The ESCWA guidelines on fostering innovation in the public sector of the Arab region provides government officials with models and information on activating and sustaining innovation in the public sector.[59]

Governments plan to develop digital e-governance tools, make data available to citizens and entrepreneurs, and leverage the crowd to source ideas for better governance. An important means for public accountability and performance assessment is technology, which can help Governments to measure and evaluate programmes. As most Arab Governments have adopted e-government strategies, continuous update is required. Citizens will feel a strong sense of trust in government when records are easily accessible, and fees/taxes are easily paid online without fear of corruption or incompetence. For businesses, that trust will be even more important, as government permits and record-keeping, tax collection and data management become more effective and secure. Some countries have turned to crowd-sourced digital tools as a means of measuring the effectiveness of their policies. Surveys can indicate how well government processes are working, what problems there are and the general satisfaction of citizens with the system and government programmes.

Governments have a leading role in enabling an equal-opportunity economic system. Inequalities exist across societies, and innovation often will exacerbate those inequalities by creating groups of entrepreneurs and investors that amass great wealth from the adoption of their innovations. The use of technology in urban environments is cutting costs of medicines and other items through innovation, and will contribute to reduce disparities. Ultimately, the culture change brought about by positive technology used for community and social inclusion has shown to lead to a safer, more engaged society. The proper adoption and transfer of technologies are greatly facilitated by adequate regulations and effective governance. One thing is clear: "Technology is not destiny; economic incentives and public policy can play a significant role in shaping the direction and effects of technological change."[60]

There is the need, also, to develop or refresh regulations designed to protect the public from harm and to ensure fairness in economic competition.[61] Governance of ecosystem interactions among the various stakeholders remains a public challenge; local governments can play leading roles with international organizations and civil society to continuously assess and improve the process. "Harnessing 4IR opportunities and proactively managing related risks will require a transformation of the 'enabling environment' – namely the governance frameworks and policy protocols, investment and financing models, the prevailing incentives for technology development, and the nature of societal engagement."[62]

The above priorities are not expected to be addressed by the same approach or magnitude by all Arab countries, because local context and constraints determine national agendas and rates of application.

IV. Impactful Technologies for a Promising Future

A. International practices from the United States and the European Union

Like the United States and the European Union, the Arab region is characterized by a diverse economic and geographic landscape. In the United States, major government agencies have built their innovation capacity. A significant proportion of R&D occurs within government facilities, such as the Departments of Defense and Energy and the National Institutes of Health. Each of these agencies has invested in training its own staff about innovation commercialization, entrepreneurship and licensing technologies for the private sector. Each agency has developed policies internally and set up alliances with corporations, venture capitalists and industry in a manner similar to the way technology transfer offices operate from universities and other research centres. Each agency has set up its own high-level commission, with experts from the public and private sectors, to focus on specific technologies deemed most important.

These commissions provided insights into the direction of investment, opportunity and where the Government of the United States needed to develop expertise in order to regulate and lead effectively. The White House Office of Science and Technology Policy coordinates the update of the National Innovation Strategy every two years. While the specifics of American policy will be different from those of Arab countries, the general nature of policy and change will be the same. On the regulatory side, the United States has focused on making it easier for technology to be commercialized and scaled as a private enterprise.

One effective measure was the legalization of crowdfunding, the practice whereby many small investors can invest in a company, rather than a smaller, more elite group of experienced, or accredited investors. That move has unlocked hundreds of millions of dollars in capital for small entrepreneurs who might not have received venture capital equity investments or bank loans because of the R&D-driven nature of their innovations. In the areas of biologics and energy, many of the most impressive innovations in the United States originated from government sources and there was no legal ability to spin those technologies into companies. Many Arab Governments have similar challenges. For example, public universities or Governments own intellectual property created by research. That situation has created little incentive to commercialize research among faculty or researchers in the region.

On the programmes and capital side, the United States has transitioned its outlook on economic development from one of infrastructure to one of innovation and entrepreneurship. Multiple government agencies have created programmes to support local innovation centres, entrepreneurship incubators and university entrepreneurship programmes. United States government agencies such as the Small Business Administration (SBA) made capital available to venture funds for investment in start-ups. Traditionally, the SBA lent capital to banks to re-lend to small businesses, which were often viewed as higher risk. Nearly every major United States government agency created an R&D commercialization programme that encouraged research grant recipients to think about the economic value and social applications of their work. The programmes provided additional capital for institutions to look at commercialization, flexibility in the use of grant funds for entrepreneurial preparation and fast tracks for patent filings.

The European Union has taken steps to develop its own technological innovation, technology and entrepreneurship systems. Individual European countries, such as Finland, Germany, Spain and the United Kingdom of Great Britain and Northern Ireland, have developed policies friendly to innovation and entrepreneurship. Each country has taken a slightly different path. Spain urged its large companies, such as Telefonica and Banco Santander, to anchor the Spanish entrepreneurship ecosystem by investing in new technologies, incubating technologies and developing services for technology start-ups. Finland and Norway developed technology clusters centred on their national industrial leaders, the oil and gas sectors. The ecosystems being built will focus on big data for the energy sector.

Germany and the United Kingdom followed a model similar to the United States by making it easier for technology to be commercialized and for investors to provide capital for high-risk technologies. In addition, both have leveraged their historic apprenticeship programmes to connect young people with start-ups. Arab countries should decide on the level of technology cooperation they want to have among themselves. The League of Arab States, ESCWA and other United Nations regional entities could provide instrumental platforms to support cooperation among them.

B. National technology strategies and policies

The accelerating pace of technology change will require more adaptation, planning, design and control from individuals, Governments, community institutions and enterprises. As a result, both policymakers and business managers need to plan ahead and try to account for future trends in technology.

There are many models to select from when it comes to the best technology and innovation policies to emulate. Each Arab country can develop its own set of strategies to address issues of appropriateness, reliability and affordability. The focus of policy should be reorienting mindsets and behaviours towards sustainable development. In this manner, STI-problem statements would be rephrased to float sustainable development challenges, and the focus of education and research policy would be more on building innovative capacity than on simple conventional detached technology transfer. In addition, practical policies should enhance an environment where the private sector is engaged and incentivized in the formulation of STI objectives.

Policy must be evidence based and benefit from current data science through the set-up of monitoring, evaluation and assessment tools, thus improving coherence and effectiveness. STI policies would be able to foster long-term innovation capacity. They would not be limited to the supply side, such as public R&D spending, but also include demand-side policies. However, that would require dynamic policy formulation regularly updated to reflect changing realities. Unlike previous industrial revolutions, the current fourth version fosters a winner-takes-all scenario, likely to exacerbate income disparities and inequality. That would have an effect on policy formulation, which would need to balance economic development with social cohesion. One way to achieve that would be to promote wider support for, and involvement in, research and innovation. That would also widen the science base and accelerate the transfer, exploitation and commercialization of public research.

Many Arab Governments have embarked on STI policies that are part of broader national strategies. Box 2 provides examples of those strategies.

Arab countries acknowledged early the importance of developing national and regional strategies to build an information society linked to socioeconomic development. Many have prepared and/or updated their national strategies. Those strategies will help Governments to leverage digital economy transformations to address the challenges they face. Those challenges include large cohorts of unemployed youth, stagnant growth and, for some, political instability and conflict. The aim is to create a path for Arab countries towards inclusive and sustainable economic growth.

Box 2. Examples of Arab technology-related strategies

- ✓ Bahrain National Research and Development Strategy
- ✓ Egypt's Industrial Development Strategy
- ✓ National science, technology and innovation policies in Iraq, Jordan, Lebanon, Mauritania, Oman, the State of Palestine, the Sudan, the Syrian Arab Republic and the United Arab Emirates
- ✓ Kuwait's National Policy on Innovation
- ✓ Libya's National Research and Development and Technology Transfer Strategy
- ✓ Morocco's National Innovation Strategy
- ✓ Qatar's National Vision 2030
- ✓ Saudi Arabia's National Policy for STI and 2030 Vision
- ✓ Tunisia's National Strategy for the Green Economy
- ✓ Yemen's Law on Incentives for Science, Technology and Innovation

C. Invigorated national research, development and innovation ecosystems

In many Arab countries, national innovation systems are being established as part of a drive to implement national strategies. Between 2015 and 2017, ESCWA implemented a project in Egypt, Lebanon, Mauritania, Morocco, the Sudan, Tunisia and Oman to enhance the capacity of national innovation systems by updating the related legislation and policies, and by establishing national technology transfer offices linked to universities and research institutions to facilitate the partnership between the research community, the economic development sector, the industry and relevant governmental departments. Unfortunately, the partnerships and discussions often get caught up in issues of intellectual property (IP). But technology transfer is much more than IP, which cannot help to get the technology to work, or to build a team of people, or to change consumer behaviour so that the technology can be useful. While progress has been made in this area, the challenges of IP management will be resolved only when there is a critical mass of technology development that has investors, start-up teams and cross-border partnerships interested but being held back because of IP issues.

The technology transfer and innovation collaboration must have four pillars, as follows.[63]

1. The private sector must be encouraged to support local R&D as a long-term investment in the region.
2. Universities, the private sector and government researchers must collaborate better.
3. Stronger partnerships must be developed with international centres of excellence in terms of research and access to technology.
4. Regional frameworks must be set up to allow for scaling up innovation.

D. Purposeful investments

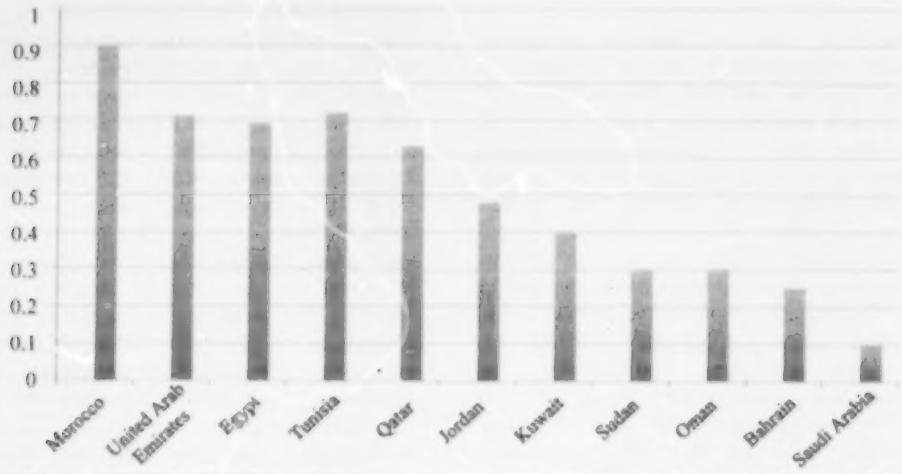
Economic development in many cases has moved from investments in infrastructure and public works towards investments in entrepreneurial ecosystems, including accelerators, incubators, entrepreneurship education programmes and government-sponsored start-up funds. Universities are reorganizing themselves around innovation as a means of attracting students and faculty, and as a revenue stream.

The importance of R&D spending depends as much on its business model as its amount. While public R&D leverages national systems to provide common innovation infrastructure, private R&D develops from endogenous idea-driven growth and enhances the dynamic of innovation clusters. An imbalance in the mix of R&D expenditure can lead to missed opportunities. When budgets are too focused on academic R&D, that can even lead to financial losses, as other countries pick up the research and develop their own commercial applications. It is not necessary to focus all research in academic institutions. However, rigorous research into fundamental questions, while not perhaps having immediate or direct relevance to businesses, could lead to unexpected practical applications. By regularly engaging with business and industry, academic researchers can ascertain whether their research areas are relevant to practitioners, and see if their research has applied uses, to specific organizational settings or in a more generalized way to other settings.

STI funding is unevenly distributed across and within Arab countries. There is a trend for strong institutional change in policy towards research funding and a diversification of funding sources. Across the Arab region, R&D funding makes up an average of 0.6 per cent of GDP, lagging behind the rest of the world's average 2 per cent of GDP. Economic strength does not always translate into higher rankings in terms of innovation and scientific research indices, and Arab countries with lower incomes still generate significant STI outcomes in many cases.

Regional trends have changed since 2010. Most Arab countries have started committing a higher proportion of their GDP to R&D. For example, as a percentage of GDP, R&D funding increased from 0.27 per cent in 2007 to 0.72 per cent in 2015 in Egypt, and from 0.1 per cent to 0.3 per cent in Kuwait.[64] The GCC countries created venture funds for local start-up investment opportunities. In Kuwait, Qatar, Oman, Saudi Arabia and the United Arab Emirates, Governments created national investment funds that make capital available to local entrepreneurs. In some countries, such as Bahrain, Saudi Arabia and the United Arab Emirates, global start-up programmes were introduced to incubate local start-ups.

Figure 6. R&D expenditure as percentage of GDP in selected Arab countries, 2015



Source: Based on UNESCO Institute of Statistics data. Available at http://www.unesco.org/new/en/media-services/single-view/news/how_much_do_countries_invest_in_rd_new_unesco_data_tool_re (accessed on 15 February 2018).

There are multiple global trends in technology that the region should evaluate and selectively invest in before missing out. They include the areas that follow.

Physical sciences, agriculture, energy and manufacturing. There are multiple breakthroughs in the fields of the physical sciences, including chemistry and physics, labelled nanotechnology and biotechnology, that are affecting agriculture, energy production and storage, as well as manufacturing. There is a great need for investment to improve food production to feed the growing population of the Arab region while utilizing land more efficiently, doing so in a way that reduces water scarcity.

Life sciences – medicine, diagnostics and medical devices. In the life sciences, major breakthroughs are occurring worldwide. The combination of big data and research investment in the treatment of diseases like cancer, HIV/AIDS, malaria and tuberculosis, has led to a boom in drug discovery and medical-device creation. Leapfrog pharmaceutical industrial development and production have taken place in many Arab countries, such as Jordan. Leading research on drug development at universities in countries such as Kuwait, Lebanon, Morocco, Qatar, Saudi Arabia, Tunisia and the United Arab Emirates is poised to develop effective drugs. In the area of diagnostics and medical devices, Arab countries would do well to invest in the purchase and collaborative technology transfer of new products, which, combined with telemedicine, would improve the chances that diagnoses and treatments could occur more rapidly and with less error. According to research by the Economist Intelligence Unit, in 2016, Arab countries spent nearly 3 per cent of their GDP on health care.[65]

Big data and data analytics. The combination of datasets moving online and the growth in computation power has led to the industry known as big data and data analytics. While Governments, universities and companies have always kept datasets, it was impossible to mine those data effectively until they were online and connected. Now, organizations are able to analyse all their data – whether about customers, innovation, human resources, marketing or finance – and gather insights to improve their businesses. There is significant potential for applications in health care, education, governance, security, transportation and sustainable consumption. For digital Arabic content, however, there are unique challenges regarding natural language processing and related AI solutions.

Connected devices: IoT. The IoT is slated to become even bigger than the current Internet, because it will connect objects. According to the Consumer Electronics Association, objects will be interconnected seven times more than humans.[66] To date, Arab countries do not have many IoT start-ups, even though the most immediate applications would be in energy, logistics, supply chain, shipping and retail – areas where the Arab region is strong. 3D printing is considered to have significant potential for the region. Rapid prototyping laboratories, schools and universities, remote towns, small companies and others can manufacture items without the high fixed costs of contract manufacturing in large quantities.

Investing holistically in the technologies mentioned above would create opportunities for jobs, companies and social transformation. However, those technologies would also result in certain job loss and industry displacement, along with income inequality.

E. Sustainable production

In Arab countries, there are many efforts to scale up successful technologies, notably in mature sustainable energy technologies such as solar and wind power. By 2015, large-scale projects had already started. For example, the Moroccan Agency for Solar Energy identified five potential sites suitable for concentrated solar power and photovoltaic plants. In 2013, the United Arab Emirates launched the 13-megawatt Mohammed bin Rashid Al Maktoum Solar Park. The park is designed to serve as a hub for technical training and innovation. It is designed to scale up, with largely automated systems that rely on very little manpower and water. The United Arab Emirates plans to expand the park to 1,000 megawatts by 2030 and generate about 15 per cent of the country's projected demand. Most other Arab countries have smaller-scale implementations of sustainable energy.

Most of the effective implementations are in solar power, already regarded as a mature technology. Private investment is becoming increasingly attracted to that type of investment in the region, especially in Jordan and Lebanon, where the level of private-sector investment caused the local photovoltaic solar energy market to triple between 2014 and 2015. Saudi Arabia has ambitious sustainable production plans as well.

New technologies build on the foundation made by proven technologies. New technologies are better able to leverage regional integration and complementarity in all areas related to STIs, such as investment, talent, markets, resources, opportunities and capacity. Appropriate technologies are needed to confront the impact of climate change on the Arab region, through strengthening education and raising awareness. Local capacity needs to be increased in terms of climate change mitigation, adaptation, impact reduction and early warning, in part by focusing on women, youth and local marginalized communities.

Sustainable cities need the innovations in energy use, water consumption, pollution and waste management, transportation, security and housing. The World Bank estimates that nearly 80 per cent of the world's population will be based in cities by 2045.[67] That will put tremendous pressure on cities like Amman, Baghdad, Cairo, Casablanca, Dubai and Riyadh. Such cities will need to manage the needs of their growing domestic populations and, in the case of Amman, the integration of refugees from conflict-ridden cities. Social media is beginning to play a critical role in educating people about decisions made in their communities that affect water, air, waste management, transportation and quality of life.

Through online advocacy, we are seeing empowered citizens around the world push for sustainability. The creation of local content and opportunities will be part of building more cohesive communities. The lack of cohesion is partially explained by the fact that very little locally developed IP and domestically owned content is currently available in Arabic. Sustainable communities are those in which people feel that they belong. Generating and having access to local content is part of that.

V. Key Messages

The implications of technology and innovation on economy and society are vast. A single set of recommendations can be neither accurate nor efficient. Rather, a continuous improvement and maintenance scheme for any action road map needs to be implemented. Arab countries have different geographies and demographics. They cannot be addressed as one group despite being bound by language, culture, history, future and well-being. Regardless of the area of innovation, the technology opportunity or the available capital, each Arab country will need to develop specific, targeted priorities to harness technology and innovation for sustainable development, with low associated potential damage and risks.

Available technology is the most efficient choice for sustainable development. The SDGs provide a comprehensive framework with which to develop effective technology and innovation programmes. The digital technology component of SDG targets focuses on the Internet, social media, data analytics, mobile applications and cloud computing. In addition, innovation should focus on breakthroughs in food sciences, life sciences and advanced materials, including manufacturing processes, green technologies, drug discovery, medical devices, routers, robotics, drones and 3D printing. Such solutions enabled by technology and innovation, are the most effective means of implementing the SDGs.

Embracing technology is inevitable. Arab countries must align their national efforts and initiatives towards creating a productive ecosystem capable of harnessing advanced R&D efforts to address local challenges and collaborate with external partners on technology development. Because the various applications and products of FTs are borderless, it is crucial to understand and localize applications to serve local priorities and protect local assets and populations. Investors from around the world are likely to begin investing in start-ups based in the Arab region. There will be a tipping point when the world becomes aware that the Arab region is not only a source of oil but also contains cities such as Amman, Beirut, Cairo, Casablanca, Dubai, Jeddah and Tunis, which could be good hosts for developing products with local talent. Policies are needed to incentivize private investments and FDI for technology development, innovation and knowledge transfer among local businesses, universities and multinational corporations.

Winning the race with 'dark avatars' of technology. The use of FTs for sustainable development creates opportunities with multiplier effects, but also poses challenges to Governments and societies. To increase the positive impact of technologies and minimize risks, regulations and policies are urgently needed to provide standardized, stable foundations. In addressing appropriateness of technology, there are many mitigating measures that allow parents, schools and Governments to better deal with the dark side of technology, which includes inappropriate content. However, a broad policy to limit content might significantly hamper a country's ability to achieve the SDGs in other areas, where open access to information is important.

Countries must find ways to ensure that appropriate content is available without placing too many personal biases on what could be judged as inappropriate content. Countries must also develop strong laws against hacking, the infiltration of computer networks by rogue elements in order to cause mischief, steal data or wreak havoc on society. There is a need for significant investment in time and resources to build cybersecurity defences and to train personnel to identify hacking. For the Internet and technology to be reliable, they must be considered trustworthy. Policies and regulations must be implemented to deal with frontier issues of technology such as AI, drones, driverless cars and genetic modification. A possible benefit from a regional approach would be to spot more efficiently the negative externalities related to technology, such as the misuse of social media, so that authorities and security agencies can better track detrimental trends and online activity before they spread.

Public sector: convener, regulator, promoter, user. To create an effective policy framework for the Arab region, several critical questions must be answered about the capacity of the region to innovate versus integrate innovation and technology

developed externally. Governments could begin to look at sector and market intelligence, along with industry reports, local events feedback and best practices, to build programmes that could further extend the capabilities of their start-up ecosysteins.

The successful policy mix would do the following things.

- Support education and technic al training, in order to supplement R&D acavities.
- Support capacity-building in the public sector, to better ensure science policy interface.
- Ensure that policies, in general, do not hinder future markets for technical innovations. A stable policy environment would reassure investors and prevent short-term political pressures that could have long-lasting, unforeseen effects.
- Avoid picking winners and generally support a suite of options. Funding is best channelled through a variety of complementary entities, to better promote competition between actors and technologies.
- Create innovative solutions to address the development challenges facing Arab countries, including in the water, energy, food and climate sectors.
- Involve stakeholders, document opinions, and communicate national visions and priorities.
- Focus on action.
- Adopt a feed-forward orientation.

In addition to integrating ICTs and other technologies into their industries and infrastructure, Arab countries must increase start-up activities in the region. It is important to ensure that computers and mobile phones have the needed apps and tools for more efficiency and optimization. The solution rests in developing the best-adapted type of technologies, and in managing the transfer of skills and knowledge to promote local empowerment.

Governments can boost the impact of technologies during their infancy. Once it is clear that a technology can be transformative, policymakers should begin to think about the possible impacts and the gates that should be placed along the way. The idea is not to stifle innovation or the growth of new companies, but to prepare for the challenges ahead. Policymakers must monitor the potential impacts of early stage technologies in order to plan for possible disruption, displacement and economic distortion. Government departments should constantly monitor the ways in which technology might change different sectors, for example in online learning or water desalination, and plan suitable optimization strategies. Some of the most common strategies are to leverage high-level advisory panels of experts to share knowledge and create programmes that form a coherent overall strategy.

Private sector: developer, innovator, user, investor, exporter. It is important for businesses to avoid the traditional partition of problems and limited vision of drawing a virtual box around the part that they control. Businesses increasingly must manage a set of competing priorities, which could distract them from the adverse impact of disruptive technologies. Advanced technology will be a 'game changer' that will require businesses to ensure that they remain competitive.

The way forward is for businesses to operate in a business ecosystem where they can focus on their own critical path for market differentiation, while their partners assist them in the day-to-day running of other systems. That is best done in a context of partnerships between the public and private sectors, and where R&D and business development are well coordinated. For Arab countries, acceleration is needed for the promotion of idea generation, accessing perspectives and research, and making each round of idea generation more complex than the previous one. It involves prototyping, piloting and implementing multiple ideas in parallel – a situation called rapid prototyping – and making decisions quickly about which ideas are progressing and which are not.

In the second stage of acceleration, organizations must prepare to go through those steps again and again until successful ideas are proven and paired with the capital and partnerships needed. Organizations must identify seed funding, business leaders with experience. Companies or non-governmental organizations (NGOs) that can move forward must be created. Accelerators can be used in nearly any sector, as well as by Governments for their own programmes, and for NGOs to launch social innovations.

Arab innovators must be able to raise funds from investors or raise debt capital from friends/family or banks. In either case, it is important to have examples of start-ups where technology entrepreneurs can showcase their products and companies in order to secure capital. Those entrepreneurs also need support with connections to large corporations and government agencies in order to secure contracts.

The role of the private sector is paramount. Governments should encourage the private sector to provide more than the classical role of corporate social responsibilities. Advanced and agile forms of public private partnerships need to be put in place through government programmes and regulatory reforms.

Civil society: trainer, advocate, monitor, governance, user. Civil society bears an important responsibility for monitoring the governance, security and privacy of technology deployment and its fair dissemination of benefits. It is important for specialized groups to advocate access to technological tools in order to support inclusive and sustainable development for all in the Arab region.

Civil society organizations that are in close touch with communities and have access to decision makers can play a critical role in ensuring the link between the expansion of technology and the advancement of societies. Ensuring that marginalized and disadvantaged communities benefit from technological advancement and have access to affordable technology is key to reducing inequality gaps. Civil society can also play the role of watchdog in order to ensure transparent and accountable governance in the technology sector.

Civil society can thus benchmark comparable international technology markets and advocate the affordability of technology, the Internet, services and critical content. Civil society should be encouraged to advocate access to information and reliable data, especially from government sources. That is crucial, because data are the basis for frontier technologies and smart applications.

Civil society can also keep lifelong learning programmes on national planning agendas to improve skills and to retrain at all ages. That type of capacity-building scheme becomes ever more relevant in terms of FTs in local communities, where the skills required are likely to change. Finally, civil society must put pressure on Governments to continue introducing and regulating the use of FTs and emphasize the advancement that technology can create in terms of increasing opportunities for youth.

Proposed ESCWA role

The ESCWA secretariat can assist member States in leveraging artificial intelligence and other frontier technologies to achieve sustainable development, and in maximizing their benefits while lowering the inevitable attached risks. ESCWA can specifically provide support in the activities summarized below.

1. Draft technology-related policies and strategies that foster an enabling environment, including through highlighting the need for government leadership at critical junctions of the Fourth Industrial Revolution; supporting the update of regulations to speed up productivity, maximize efficiency benefits and lower the related risks; fostering individual and societal privacy and security; improving skills and retraining young people; ensuring inclusive growth and reaching social fairness; and supporting the ethics of effective governance. Activities can also introduce devising incentive economic programmes and policies to attract private sector investments in research, development and innovation, and engage with university curricula.

2. Convene regional stakeholder dialogues and conduct studies on technological innovation and scientific discoveries.

3. Disseminate knowledge and build capacity based on findings of regional studies that can provide tailored solutions.

4. Promote education and training that match the required skills, and connect research activities to the needs of local economies and societies.

5. Encourage the adoption of frontier technologies by the public sector in its operations and assist in implementing existing policies.

6. Compile best practices in adopting and localizing technology applications in areas including economic diversification, employment of youth, empowerment

of women, management of natural resources, return of refugees and reconstruction.

7. Promote adequate artificial intelligence and frontier technologies applications for SDG implementation and measurement.

Conclusion

General Assembly resolution 72/242 of 22 December 2017, titled "Impact of rapid technological change on the achievement of the Sustainable Development Goals", encourages Member States to continue considering the impact of key rapid technological changes on the achievement of the SDGs, in order to benefit from opportunities and address challenges in this regard, and to promote the development of national strategies and public policies, capacity-building and scientific engagement.

ESCWA and its member States can join efforts towards updating national technology strategies and policies; empowering the tech-savvy youth, especially girls and women; supporting competitive technology sectors; raising awareness of and leading action campaigns on frontier technologies, especially in terms of local productivity improvements; avoiding unfortunate abuse in usages and confronting the negative side of technology, especially in relation to cultural norms; and enhancing digital Arabic content.

The technology revolution holds a wealth of promises. It is unstoppable, gaining both speed and strength, cutting across all borders and aspects of life – private, public, societal and economic. If the adequate governance and harnessing tools are deployed, the positive impact on the Arab region of this revolution can be tremendous.

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25. It is also the role of Governments to provide incentives for the creation of employment opportunities at different skill levels for all groups, and to ensure equal access to quality education for less advantaged social groups so that they can also benefit from the technological revolution.

26. E/ESCWA/EDGD/2014/2, p. 84.

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